Schizotypal personality and semantic functioning: Revisiting category fluency effects in a subclinical sample

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ABSTRACT

Semantic disturbances have been proposed as a possible cause of formal thought disorder in schizophrenia. Fluency tasks, in which volunteers are asked to produce as many exemplars as they can for a given category during one minute, are usually applied to the assessment of semantic processing. However, studies associating fluency and proneness to psychosis have provided conflicting results so it is not clear whether these disturbances can be identified at subclinical stages. We conducted two experiments. In the first one, 71 volunteers completed written category fluency tasks with four semantic categories (animals, fruits, clothing and vehicles). In the second experiment, 77 new participants completed oral category and phonological fluency tasks (words starting with f, t, p and c). In both experiments, we assessed schizotypal personality and vocabulary size. Schizotypal traits were not reliably associated with either productivity or originality of the responses in any experiment. In contrast, vocabulary size significantly predicted the participants' scores in all the tasks. Along with results of other recent studies, our data cast doubt on the reliability of previous observations pointing out an association between schizotypy and lexical-semantic disturbances, at least in relation to productivity and originality in fluency tests.

1. Introduction

Semantic processing disturbances have been proposed as a cause of formal thought disorder in schizophrenia (see Doughty and Done, 2009; Pomarol-Clotet et al., 2008 for extensive reviews). The idea behind this association is that semantic activation spreads faster and further through the semantic network in patients with schizophrenia, which causes loosely related concepts to be activated during lexical-semantic processing (Spitzer, 1997). This finding has motivated several studies using the schizotypy analogue, aimed at ascertaining whether these disturbances can also be identified at subclinical stages. These kinds of studies help to understand the deficits that underlie psychotic thought disorders, avoiding confounding factors frequently observed in schizophrenia, like the use of drugs or hospitalization (Tonelli, 2014).

Schizotypal personality traits are considered an indicator of vulnerability to psychosis (Meehl, 1962), based on markers such as perceptual or cognitive distortions, interpersonal deficits and eccentric behavior, which appear in the general population as a continuum (Tonelli, 2014). Characteristics of schizotypal personality mirror those of schizophrenia, and can also be grouped into three dimensions:

positive, negative and disorganized. The positive, or psychotic, dimension is related to extravagant perceptual experiences, odd beliefs and delusion, as well as paranoia. The negative dimension is associated with aspects such as a lack of will and motivation, as well as anhedonia and flat affectivity. Finally, the disorganized dimension refers to atypically structured modes of thought and discourse, as well as odd behaviors (Kwapil and Barrantes-Vidal, 2015).

Results in category fluency tasks, in which participants are instructed to generate members of a given semantic category, such as "fruits", are considered a robust measure of semantic memory function (Neill et al., 2014a), and have been shown to be impaired in patients with schizophrenia (Henry and Crawford, 2005; Smirnova et al., 2017). Kiang and Kutas (2006) analyzed responses to four category fluency tasks in a sample of volunteers varying in schizotypal traits. Their results showed no relation between productivity and schizotypy. However, they observed a significant positive association between originality of the responses to the fruit category and disorganized and interpersonal traits. Further analyses showed a significant association between the originality of the first response of the participants to the fruit category and the three schizotypy dimensions. No effects were

observed in the responses to the other three categories (animals, vehicles and articles of clothing) or the mean originality overall. Years later, Aguilera-Ruíz et al. (2008) observed an inverse association between positive and negative schizotypy and a composite measure including category fluency and other semantic tasks, whereas Minor and Cohen (2012) reported more original responses for participants with high schizotypy scores. In contrast, Hori et al. (2008) observed no association between productivity or originality of the responses to category fluency and schizotypy. In more recent studies, Minor et al. (2015) obtained a significant positive association between disorganized, but not positive or negative, traits and productivity in a category fluency task, whereas Tan and Rossell (2017) observed a significant negative relation between disorganized schizotypy and productivity. Finally, Dinzeo et al. (2018) obtained a significant inverse relation only between negative symptoms and productivity.

In sum, three studies have observed an inverse relation between productivity in category fluency tasks and, at least, one of the three schizotypy dimensions (Aguilera-Ruíz et al., 2008; Dinzeo et al., 2018; Tan and Rossell, 2017). In contrast, one study has obtained a positive relation between the disorganized dimension and productivity (Minor et al., 2015) and two further studies have failed to show any association between schizotypy and fluency productivity (Hori et al., 2008; Kiang and Kutas, 2006). With regards to originality, two studies have shown a positive association between all or some schizotypy dimensions and originality of the responses (Kiang and Kutas, 2006; Minor and Cohen, 2012), whereas one study did not observe this association (Hori et al., 2008).

Overall, previous studies have provided mixed results, so it is still not clear whether possible semantic disturbances associated with high levels of one or more schizotypal traits can be observed through category fluency tasks, either by means of productivity or originality measures. In order to clarify this issue, we conducted two experiments. In experiment 1, we compared the results of a written category fluency task with scores in a schizotypal personality test. We used a written version of the fluency task because it allows more efficient testing of the participants in groups. Written and oral fluency tasks have been shown to run equivalent developmental courses through life (Rodríguez-Aranda, 2003) and are equally sensitive to dementia-related semantic variability (Groves-Wright et al., 2004). However, written fluency tasks lead to reduced productivity compared to the oral variant (Rodríguez-Aranda, 2003), so, in a second experiment, we introduced oral fluency tasks to rule out possible influences of production modality over our results. Moreover, we included a phonological fluency task in order to compare two similar tests involving different degree of semantic processing. Phonological fluency tasks, in which participants are asked to generate words starting with a given letter, are similar to category fluency tasks, but depend less on semantic processing (Cuetos et al., 2009; Shao et al., 2014). Results in this test have also been associated with scores in schizotypal personality tests. Thus, Cochrane et al. (2012) observed reduced productivity for volunteers with high levels of negative schizotypy but no relation with positive or disorganized symptoms. In contrast, Tsakanikos and Claridge (2005), as well as Hori et al. (2008) and, more recently, Tan et al. (2016) failed to observe any significant correlation between schizotypal traits and results in a phonological fluency test.

With this study, we aimed to clarify the relationship between semantic memory and thought disorder, assessing the responses to category fluency tasks produced by participants ranging in schizotypy. We expect schizotypal personality to have a negative effect, if any, on productivity in fluency tasks (Aguilera-Ruíz et al., 2008; Dinzeo et al., 2018; Tan and Rossell, 2017), with high schizotypy involving lower productivity. More interestingly for our aim, we hypothesize that, if thought disorder is related to enhanced semantic activation, increased schizotypy will be associated with more original responses. Moreover, this association should be stronger in the case of category fluency than in phonological fluency, due to its increased dependence on semantic

memory functioning (Henry and Crawford, 2005).

2. Methods

2.1. Participants

A group of 71 undergraduates from the University of Barcelona (63 females, mean age = 20.5, SD = 4.13) took part in experiment 1 in exchange for course credits. A group of 77 new volunteers (68 females, mean age = 20.3, SD = 2.2) took part in experiment 2. We treated all data anonymously. They were all native speakers of Spanish or Spanish-Catalan bilinguals. The university's ethics committee (Comissió de Bioètica de la Universitat de Barcelona, CBUB) approved the study protocols and all the volunteers provided written informed consent before their participation in the study.

2.2. Materials

For the category fluency task in experiment 1 the participants were asked to write as many names of items as possible from four different categories (animals, fruits, articles of clothing and vehicles) during one minute each. In experiment 2, the participants were first asked to orally produce as many names of items as possible from the four semantic categories used in the previous experiment. Then, for the phonological fluency task, they were instructed to orally produce as many words as possible starting with one of four given letters. We selected letters f and p as they are frequent initials in Spanish for which fluency norms are available (Ardila and Ostrosky, 2012; Marino and Alderete, 2010). Then, we added two other common initials in Spanish, letters t and c, to match the number of categories used in the semantic version of the task. We gave the volunteers one minute for each category or letter, and we counterbalanced the order of presentation of the four categories within the two tasks.

We assessed schizotypal personality by means of the Esquizo-Q-A questionnaire (Fonseca-Pedrero et al., 2009), a validated Spanish test consisting of 23 questions presented in a five-point Likert-like format. This test provides separate measures for three dimensions: Distortion of Reality or Positive dimension, which refers to positive symptoms such as distorted perceptive experiences, paranoid ideation and magical thinking; Negative dimension, which refers to physical and social anhedonia; and Interpersonal Disorganization or Disorganized dimension, which refers to symptoms like disorganized language and thinking, social anxiety and lack of close friends or odd behavior. Scores in this scales have been shown to significantly correlate (Fonseca-Pedrero et al., 2009) with scores in the corresponding scales of English-validated tests like SPQ-B (Raine and Benishaw, 1995) or RADS (Reynolds, 1987). Following Kiang and Kutas (2006), the participants also answered the Spanish validated version of the Peabody Picture Vocabulary Test (PPVT, Dunn and Dunn, 1997) as an estimate of vocabulary size. Given that many of our participants presented some degree of bilingualism, which has been noted to influence the performance in fluency tasks (Gollan et al., 2002; Wauters and Marquardt, 2018), an extra control measure of language dominance was introduced in experiment 2 in order to rule out possible effects of this variable in our results. In this questionnaire, participants were asked to indicate their preference for language usage in different domains using a five-point Likert scale, with higher scores indicating stronger Spanish dominance, and lower scores indicating stronger Catalan dominance.

2.3. Procedure

Experiment 1 was conducted with groups of up to ten volunteers per session. First, the participants were asked to state their age and gender, then the experiment started with the fluency tasks. After that, the volunteers were presented with the vocabulary and schizotypy tests. In experiment 2, the participants were tested individually. They were first

presented with the category fluency task, then, with the phonological fluency task. Finally they answered the vocabulary and schizotypy tests, and the language dominance questionnaire.

3. Results

3.1. Sample characteristics

In experiment 1, scores for the full schizotypy scale ranged between 25 and 86, with $M = 46.8$, $SD = 9.5$ (Positive: $M = 9.6$, $SD = 3.9$, range = 6–28; Negative: $M = 11.6$, $SD = 3.7$, range = 7–31; Disorganized: $M = 25.6$, $SD = 5$, range = 12–37). In the vocabulary test, scores were between 145 and 182 ($M = 164$, $SD = 7.4$). In experiment 2, scores for the full schizotypy scale ranged between 28 and 62, with $M = 44.3$, $SD = 6.5$ (Positive: $M = 8.4$, $SD = 2.8$, range = 6–18; Negative: $M = 11.1$, $SD = 2.4$, range = 7–18; Disorganized: $M = 24.8$, $SD = 4.9$, range = 14–37). Scores in the vocabulary test were between 147 and 180 ($M = 165$, $SD = 6.7$).

3.2. Task analysis

Statistical analyses were conducted using JASP (Jasp Team, 2017). We analyzed the results of the fluency tasks using different parameters. On the one hand, productivity corresponds to the average amount of valid items produced by each participant for each category. On the other hand, response probability refers to the percentage of participants that produce a given item. For instance, 100% of our participants produced the word "apple" in response to the fruits category in experiment 1, whereas only 1.4% of them, just one participant, produced the item "jujube" in this same category. For an easier interpretation of the results, the complements of these numbers can be considered a measure of originality. Thus, originality of the response "apple" would be 0, whereas originality of the response "jujube" would be 98.6. Table 1 presents a summary of the fluency and originality scores obtained by our participants. Following Kiang and Kutas (2006), we also analyzed the originality of the first response to each category as well as the overall typicality index t. The analysis of the first response to each category is interesting because it reflects lexical retrieval abilities for

very typical items of the category. Moreover, it is analogous to the study of responses to a free word-association task (in which volunteers are asked to produce the first word to come to their mind when presented with a given cue), whose results in terms of response originality have also been associated to schizotypal traits (Merten, 1993; Miller and Chapman, 1983). On the other hand, typicality index t refers to the mean of the ratio of each response's rank in the overall sample to the position in which a given participant produced it, hence, providing a measure of the functional organization of words within a given semantic category. Lower values of t represent higher typicality, with the minimum possible value of 1 reflecting that the items produced by the participant match the response probability rankings of the complete sample, and higher values indicating more original response sets.

As expected, productivity in the written categorical fluency task in experiment 1 was lower than that in the oral categorical fluency of experiment 2 ($t(146) = -8.955$, $p < 0.001$). Nevertheless, originality of the responses was similar between the two experiments (overall originality $t(146) = 1.158$, $p = 0.249$; originality of first response $t(146) = 0.397$, $p = 0.692$; t index $t(164) = -0.154$, $p = 878$). This result suggests that the production modality (written or oral) does not affect the originality of the responses and, hence, both versions of the task provide equivalent measures for the main purpose of our study.

In experiment 1, two-sided correlation analyses showed a significant inverse association ($p = 0.042$) between t index and scores in the positive dimension (see Table 1). Moreover, our results showed a significant positive association between scores in the fluency task and our measure of vocabulary size. Specifically, scores in the PPVT were significantly associated to overall originality ($p = 0.001$).

Given the pattern of effects observed in the first analyses, we applied Bayesian statistics in order to determine whether or not our data provided sufficient evidence to support the null or alternative hypotheses (see also Table 1). Following Wagenmakers et al. (2017) guidelines for Bayes factor interpretation, the results of our Bayesian analyses provided anecdotal-to-moderate evidence ($0.1 < BF_{10} < 1$) in favor of the null hypothesis that there is no association between the productivity and originality values of the category fluency task and the schizotypy measures. The only exception was the relation between the t index and the positive dimension, for which Bayesian analyses indicate

Table 1
Summary of the results of the two experiments.

Experiment 1 Category fluency	Mean (SD)	Pearson correlations with Positive r (BF₁₀)	Negative r (BF₁₀)	Disorganized r (BF₁₀)	Vocabulary r (BF₁₀)
Productivity	13.9 (2.0)	0.106 (0.218)	0.117 (0.238)	0.016 (0.151)	0.208 (0.658)~
Originality	53.3 (4.6)	−0.187 (0.484)	0.011 (0.150)	−0.067 (0.173)	0.380 (27.897)**
Originality First Item	22.9 (12.7)	−0.191 (0.509)	−0.232 (0.935)	−0.084 (0.189)	0.096 (0.202)
Typicality Index t	1.8 (0.3)	−0.243 (1.124*	−0.164 (0.368)	0.000 (0.149)	0.129 (0.261)
Experiment 2 Category fluency					
Productivity	17.5 (2.7)	0.013 (0.143)	−0.100 (0.206)	0.024 (0.145)	0.321 (7.601)**
Originality	52.4 (4.4)	0.044 (0.153)	−0.075 (0.175)	0.002 (0.142)	0.385 (50.969)***
Originality first item	22.1 (12.7)	0.150 (0.326)	0.122 (0.246)	0.240 (1.252)*	0.010 (0.143)
Typicality index t	1.8 (0.3)	0.048 (0.155)	0.201 (0.645)	0.147 (0.317)	0.050 (0.156)
Phonological fluency					
Productivity	12.4 (3.0)	0.106 (0.215)	−0.001 (0.142)	−0.100 (0.205)	0.362 (23.837)**
Originality	91.2 (1.8)	0.274 (2.493)*	−0.013 (0.143)	−0.161 (0.370)	0.289 (3.472)*
Originality first Item	77.6 (10.0)	0.149 (0.323)	0.179 (0.469)	0.013 (0.143)	0.267 (2.107)*
Typicality Index t	3.0 (0.6)	0.082 (0.182)	0.000 (0.142)	0.072 (0.172)	−0.179 (0.466)

r indicates Pearson correlation coefficient; BF_{10} indicates Bayes Factor for the alternative hypothesis.
~$p < 0.1$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

anecdotal evidence ($1 < BF_{10} < 3$) for the alternative hypothesis that the two variables are related. In contrast, the same analyses indicated strong evidence ($10 < BF_{10} < 30$) favoring the association between overall originality and responses to the vocabulary test.

In order to rule out a possible influence of the participant's productivity on the association between vocabulary size and originality (more overall items produced could allow more unique responses), we conducted a multiple regression analysis including originality as dependent variable and both productivity and vocabulary size as predictors. The results ($R^2 = 0.169$) indicated that the effect of vocabulary size remained significant ($\beta = 0.347$, $p = 0.003$) after including productivity ($\beta = 0.159$, $p = 0.164$).

Regarding the category fluency task in experiment 2, two-sided correlation analyses showed a significant positive association between disorganized schizotypy and originality of the first item produced in each category ($p = 0.035$). For the phonological fluency task, our results showed a significant positive association between overall originality and positive schizotypy ($p = 0.016$). Like in experiment 1, results confirmed the association between scores in both fluency tasks and vocabulary size. Scores in the PPVT were significantly associated to overall productivity ($p = 0.004$) and originality ($p < 0.001$) in the category fluency task and to overall productivity ($p = 0.001$) and originality ($p < 0.011$) as well as originality of the first responses ($p = 0.019$) in the phonological fluency test. Language dominance obtained from our bilingualism control measure was not significantly correlated to any of the fluency scores ($rs < 0.190$, $ps > 0.097$).

Bayesian analyses of the results of experiment 2 indicated that our data provides moderate evidence for the null hypothesis that there is no relation between schizotypy and productivity or originality in the two fluency tasks ($0.1 < BF_{10} < 0.33$). Exceptions to this finding are the two significant results observed in the frequentist analyses (associations between disorganized traits and originality of first response in the category fluency task, and between positive traits and overall originality in the phonological fluency task), for which Bayesian analyses indicated no reliable evidence in favor of the null or alternative hypotheses ($1 < BF_{10} < 3$). These analyses also pointed out moderate-to-very strong evidence favoring the alternative hypothesis associating productivity and overall originality to scores in the vocabulary test in both the categorical and phonological fluency tasks.

For experiment 2, we also conducted regression analyses including originality in the semantic and phonological tasks as dependent variables, and productivity and vocabulary size as predictors. The effect of vocabulary size remained significant ($\beta = 0.165$, $p = 0.044$) after including productivity ($\beta = 0.687$, $p < 0.001$) in the case of semantic fluency ($R^2 = 0.572$). However, the inclusion of productivity values ($\beta = 0.429$, $p < 0.001$) made the effect of vocabulary size disappear ($\beta = 0.134$, $p = 0.220$) in the case of phonological fluency ($R^2 = 0.244$).

4. Discussion

We aimed to replicate previous observations showing an association between schizotypal personality traits and results in category fluency tasks. Studies so far had obtained mixed results regarding this possible association. With regards to productivity, previous research has yielded both positive (Minor et al., 2015) and negative (Aguilera-Ruíz et al., 2008; Dinzeo et al., 2018; Tan and Rossell, 2017) associations between schizotypal traits and the amount of words produced in category fluency tasks. As for originality, two studies have reported more unusual responses for volunteers with higher schizotypy scores (Kiang and Kutas, 2006; Minor and Cohen, 2012). Our data, however, go in line with those reported by Hori et al. (2008) who observed no association between schizotypal personality traits and results in category fluency. We obtained similar results in two experiments with different samples of participants, using written and oral versions of the task respectively.

In experiment 2 we also included a phonological fluency task,

aiming to compare the results between two tasks involving different degrees of semantic processing. Again, in contrast to results obtained by Cochrane et al. (2012), we failed to observe a reliable association between fluency and schizotypal traits, replicating the results of several previous studies (Hori et al., 2008; Tan et al., 2016; Tsakanikos and Claridge, 2005). Hence, our initial hypotheses (reduced productivity and increased originality for higher schizotypy scores, and stronger association between schizotypy and semantic, compared to phonological, fluency) were not supported.

Although the comparison between the written and oral fluency tasks was not a main goal of the study, it is worth mentioning that, according to our data, both tasks provide similar results with regards to the originality of the responses. Further studies analyzing the originality of fluency responses could benefit from this finding, as written tasks allow for more efficient participant testing than the oral version of the procedure.

Another interesting finding of this study is related to the assessment of vocabulary size. This variable appeared to play a significant role in all the tasks, influencing originality in the written fluency task and both originality and productivity in the oral category and letter fluency tasks. The effect of vocabulary size over originality of the responses survived the inclusion of productivity scores as a covariate in the category fluency task, though not in the phonological version of the test. Vocabulary size has been previously shown to influence productivity in fluency tests (Bialystok et al., 2008; Luo et al., 2010). Our results confirm that greater availability of lexical entries allows increased productivity during these tasks, and extends this finding to the originality of the responses, at least in semantic-based fluency tests. According to our results, future studies investigating the relationship between semantic fluency and schizotypy, or any other variable, should control for vocabulary size in order to rule out possible confounds in their results. Given the absence of clinically diagnosed volunteers in our sample, our results cannot be generalized to schizophrenia patients. Nevertheless, we believe that measures of vocabulary size should also be taken into account in future studies with clinical samples aimed to confirm previously reported fluency deficits (Henry and Crawford, 2005; O'Leary et al., 2000).

An obvious source of limitations of our study could be related to a possible lack of variability in the different schizotypy dimensions in our sample, which could be responsible for the lack of effects observed. Nevertheless, our sample reflects distribution values similar to those of the test population, with our participants covering the full range of percentiles described in the test. Note, however, that the gender imbalance in the samples of the two experiments (only 12% of the participants were males) could hinder the generalizability of their results, and further studies should be conducted to ascertain whether this variable could influence our conclusions.

Finally, our results could be interpreted as indicators that schizotypy is not related to semantic processing. However, we cannot completely rule out a significant association between schizotypal traits and semantic variability based on this study. For instance, other tasks with lower executive demand, such as automatic priming, might be more adequate to assess the organization of semantic knowledge in relation to schizotypy. In semantic priming studies, recognition of a target word is expected to be easier if it is preceded by a semantically related prime. When short stimulus onset asynchronies between prime and target words are used, the cognitive process responsible for priming effects is considered to be automatic and, thus, free from strategic or explicit cognitive control. Previous studies have associated variability in schizotypal traits with differences in automatic priming effects (Johnston et al., 2008; Kiang et al., 2010; Neill et al., 2014b), which could indicate that these kinds of tasks are more suitable to detect subtle differences in semantic processing in subclinical samples (Tan and Rossell, 2017; Wang et al., 2013).

In sum, along with results of other recent studies, our data cast doubt on the reliability of previous observations pointing out an

association between schizotypy dimensions and lexical-semantic disturbances, at least in relation to productivity and originality in fluency tasks. Besides, our study points out the relevance of including vocabulary size measures in future research based on semantic fluency tests.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2018.11.074.

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